ASSESSING THE COSTS AND BENEFITS OF REDUCING GREENHOUSE GAS EMISSIONS

Preliminary Assessment

The Administration employed a variety of tools to assess the various possible costs and non-climate benefits of our emissions reduction policy. Our overall conclusion is that the net costs of the Administration's policies to reduce emissions are likely to be relatively modest, assuming those reductions are undertaken in an efficient manner with effective international trading, the Clean Development Mechanism, meaningful developing country participation, and sound domestic policies. That potential small net premium, even excluding the benefits of mitigating climate change, purchases a partial insurance policy against a serious environmental threat. Further, although we think the economic benefits of mitigating climate change are subject to too many uncertainties to quantify, those benefits over time are likely to be real and large (see p. 69).

In reaching this conclusion, the Administration has drawn on the insights of a wide range of models of the energy sector and economy over the next 25 years, including but not limited to the results of the Stanford Energy Modeling Forum (Gaskins and Weyant 1993, Weyant 1997), the Intergovernmental Panel of Climate Change's review of the economic and social dimensions of climate change (Bruce et al. 1996), the work of the OECD on the economic dimensions and policy responses to global warming (OECD 1998), and the Administration's staff-level interagency analysis (Interagency Analytical Team 1997). In addition, the Administration used other tools, such as a meta-analysis (Repetto and Austin 1997), overviews of the domestic and international energy sectors (Energy Information Administration 1997a, d), simple statistics regarding energy efficiency, greenhouse gas emissions, and economic indicators from World Bank, International Energy Agency, and Energy Information Administration databases, and basic economic reasoning.

The conclusion that the impact of the Administration's policies to address the risks of climate change will be modest is not entirely dependent upon, but is fully consistent with, formal model results. The Administration continues to believe that there are limitations to relying on any single model to assess the economic impact of the Kyoto Protocol. However, model results can further inform and improve the understanding of the effects of climate change policy. To complement the economic analysis of the Administration's policy to address climate change, we have conducted an illustrative assessment with a modified version of the Second Generation Model. The results from the SGM substantiate the conclusion that the economic effects of an efficient, effective, and global policy to address the risks of climate change will be modest.

Difficulties of an Economic Analysis of Climate Change

The difficulties associated with economic analysis of climate change fall into three broad categories. First are the uncertainties that still remain over the operational considerations of the treaty, necessitating assumptions on which the analysis is predicated. Second are the inherent limitations of available models to analyze the costs of abating emissions. Third, it is extremely difficult to quantify the long-term economic benefits of climate change mitigation, although such benefits are the motivation for the Kyoto Protocol. Economists have a difficult time projecting the behavior of the economy over the next quarter or year, let alone over the next two decades. The scale of the forecasting exercise is therefore daunting, and any specific results should be treated with substantial caution.

Uncertainties in the International Effort to Combat Climate Change

The Kyoto Protocol provides the foundation for the international effort to address climate change. However, the Protocol is still a work-in-progress. Uncertainties about the ultimate characteristics of the international climate change policy regime provide challenges in conducting an economic assessment.

For example, some of the rules pertaining to the flexibility mechanisms in the Kyoto Protocol, such as emissions trading and carbon sinks, require further delineation. These issues and others, including the role of developing countries, will be addressed in future negotiations.

More importantly, the international community has not yet negotiated agreements to limit greenhouse gas emissions beyond the 2008 to 2012 window. The emissions targets established in Kyoto provide for the first of many necessary steps to address the risks of climate change. The first step is critical because it sends a signal to the private sector regarding the value of reducing greenhouse gas emissions and it begins the task of reducing emissions relative to the business as usual path. However, subsequent steps are also necessary to address climate change risks adequately. Lack of knowledge regarding what the subsequent steps will be complicates any analysis of climate change mitigation.

Inherent Limitations of Models

In addition to these uncertainties about the details of the international effort to address climate change, there are the inherent limitations of the models used to evaluate that effort. Even within a given model, answers depend critically on the precise nature of the question asked. For example, the costs of emissions reductions depend on the extent of global participation and international trading that a treaty is assumed to feature. But in addition to the dependence of the results from a given model on the precise assumptions, different models can give different answers even when all the assumptions are specified to be the same -- a concrete illustration of the range of uncertainty surrounding the predictions of any one individual model.

Benefits of Averting Climate Change

As discussed in the risks of climate change section, it is evident that the benefits of averting climate change are potentially very large. There are several difficulties associated with monetizing the benefits of averting the risks of climate change. First, there is the uncertainty relating to the specific effects of climate change (e.g., would the planet be 2 or 6 º F warmer in 2100, or some level within that range, without any measures to abate emissions). Second, the uncertainty over the extent that benefits should be discounted because they occur in the distant future presents challenges. Since the benefits of stemming future climate change accrue over not only decades but centuries, small changes in the discount rate can produce substantial changes in the results. Third, the benefits depend on global emissions paths after the 2008 to 2012 budget period specified in Kyoto. To calculate the benefits of averting climate change-induced damages, it is necessary to know the emissions path for many years beyond 2012. Thus while the benefits of getting started on the Kyoto path to reducing greenhouse gas emissions may be large over time, we cannot estimate these benefits without knowing where the path goes in the years after the Kyoto compliance period.

Illustrative Calculations: Methodology

Recognizing the difficulties inherent in an economic analysis, the Administration nonetheless undertook an examination of the economic impact on the U.S. economy of the Kyoto Protocol. Since no one model exists to handle all of the parameters of the Kyoto agreement, several tools had to be used to calculate the estimated costs of climate policy. First, the Administration constructed emissions baselines for all six types of greenhouse gases and 2010 business as usual levels for these gases for Annex I countries. These emissions estimates would serve as the basis for calculating the emissions reductions required to achieve the Kyoto targets. Second, we developed cost curves for reducing greenhouse gas emissions. For carbon dioxide, marginal abatement cost curves were derived from more than 60 model runs with the Second Generation Model. For other greenhouse gases, we used a bottom-up marginal abatement cost curve developed by the Interagency Analytical Team (1997). Third, we assessed several different trading scenarios based on the required emissions reductions and the constructed cost curves. Equalizing marginal costs across countries and regions generated a common permit price across the trading bloc. Fourth, we calculated the effects of the permit price on energy prices, energy consumption, GDP, investment, and consumption.

Construction of a 6 Gas Baseline and 2010 "Business as Usual" Baseline

To assess the potential economic impact of the Kyoto Protocol, it was first necessary to construct 1990/1995 baseline emissions and business as usual emissions paths that account for all six categories of greenhouse gases. While estimates of 1990 emissions and 2010 projected emissions for carbon dioxide are widely available for most Annex I countries and many large Non-Annex I countries, the Administration gathered data on the other greenhouse gases from more than 25 submitted National Communications to the Framework Convention on Climate Change, official reports of the Framework Convention, and Environmental Protection Agency and Department of Energy analyses. In some cases, we made extrapolations from one country to another based on common characteristics (e.g., GDP). These data provide the basis for our preliminary estimates until the parties to the Framework Convention provide more detailed information on historical and projected emissions of all six categories of greenhouse gases. With these baseline estimates, the Administration estimated the magnitude of the emissions reductions required of Annex I countries under the Protocol.

Carbon Dioxide Emissions

For projections of carbon dioxide, we used the business as usual projections in the Second Generation Model, with the exception of the United States, where we used the more recent Energy Information Administration (1997a) estimate of 2010 BAU for energy-based CO_2 and the Climate Action Report (1997) projection for non-energy-based CO_2. For the European Union, the Administration adjusted the Western Europe value in SGM to reflect the non-participation of Iceland, Norway, Switzerland, and Turkey in the E.U. bubble. Based on CO_2 emissions estimates from the Carbon Dioxide Information Analysis Center, we deducted 66.1 MMTCE from the Western Europe estimate to derive the E.U. 1990 baseline CO_2 emissions value. For 2010 BAU, 85 MMTCE were deducted from the Western Europe 2010 estimate.[12]

Emissions of Other Greenhouse Gases

For projections of the other five categories of greenhouse gases, we used information provided in the national communications to the Framework Convention on Climate Change. In some cases, 2010 emissions were extrapolated from projections of 2000 emissions levels. In addition, some projections in emissions were based on growth rates in comparable countries. For a country-by-country discussion of the emissions baselines derivations, refer to Appendix B.

Converting to Carbon Equivalence

In all cases where data are provided in tons of gas, or tons of carbon dioxide equivalent, the Administration converted the data to tons of carbon equivalent based on their 100-year time horizon global warming potential (Houghton et al. 1996; refer to Table 2). Some countries aggregated all HFCs into one value (and in some cases, all PFCs into one value). We constructed an HFC weight and a PFC weight based on specific HFC and PFC emissions in the United States in 1995. For HFCs, the following weight was used:

$$[2 * GWP(HFC\text{-}134a) + GWP(HFC\text{-}23)]/3 = 1300$$

HFC-134a was 52% and HFC-23 was 21% of all U.S. HFC emissions in 1995 (Climate Action Report 1997). For PFCs, the following weight was used:

[12] We assumed that these four non-E.U. European countries would experience the same emissions growth rate as the E.U. over the 1990-2010 period to calculate their 2010 emissions.

$$[2*GWP(CF_4) + GWP(C_6F_{14})]/3 = 1855$$

CF_4 was about 60% and PFC/PFPEs[13] were about 25% of all U.S. PFC emissions in 1995 (Climate Action Report 1997).

Carbon Sinks

The Kyoto Protocol specifies that removals of CO_2 by certain kinds of sinks count toward meeting emissions targets. Mechanisms are also provided for adding new categories of sinks. Very preliminary estimates suggest that incorporating the gains from carbon sinks throughout the world could substantially reduce the costs of meeting the Kyoto target, on top of the gains from trading among Annex I countries. Such gains could be substantial under business as usual and even larger after taking into account the additional effects of government policy. Government policy could, for example, provide an incentive to increase the activities qualifying as allowable sinks, like tree-planting. However, no model has yet tried to account for such additional effects. Because the quantitative uncertainty is so large, we do not yet have an estimate with which we are comfortable. But we expect that complete modeling of the Kyoto provision pertaining to sinks would have favorable effects on projected costs. For the analysis reported here, the Administration employed a conservative assumption that all countries' sinks equaled zero and that no country would implement policies to stimulate the creation of carbon sinks.

Kyoto Targets

The emissions targets for Annex I countries were from Annex B of the Kyoto Protocol. For Non-Annex I countries, the assumed emissions targets were equal to those countries' business as usual emissions levels in 2010.

Constructing Marginal Abatement Cost Functions

To construct marginal abatement cost functions for carbon dioxide, the Administration used model results from Battelle Laboratory's Second Generation Model (SGM). SGM is a computable general equilibrium model designed to provide

[13] The Climate Action Report (1997) notes that "PFC/PFPEs are a proxy for many diverse PFCs and perfluoropolyethers (PFPEs), which are beginning to be used in solvent applications. Global warming potential and lifetime values are based upon C_6F_{14}" (p. 71).

estimates of the economic costs of actions to reduce carbon dioxide emissions.[14] SGM models the energy sector in greater detail than other sectors, so it can provide information on the trade-offs in the consumption of different fuels under a policy to reduce carbon dioxide emissions. It also serves the purpose of evaluating the effects of international emissions trading, because it includes twelve countries and regions (see Table 3). The capacity of the SGM model to take into account international trading is an obvious virtue of this model relative to the other two models used in the Interagency Analytical Team process, both of which only modeled the economic effects of emissions reductions in the United States. The SGM, like all models used to assess economic effects, has strengths and weaknesses. Therefore, the results from this analysis should be considered illustrative. However, the results of the Stanford EMF's investigation of the implications of international trading suggest that the conclusion that effective international trading can significantly reduce costs is robust (Weyant 1997).

Table 3. Countries/Regions in Second Generation Model

Annex I	**Non-Annex I**
United States	China
Western Europe	India
Former Soviet Union	Korea
Eastern Europe	Mexico
Japan	Rest of the World
Canada	
Australia	

Source: Second Generation Model

Abatement Cost Functions in Industrialized Countries

Drawing on results of more than 60 model runs from the SGM, the Administration developed country- and region-specific cost functions for carbon dioxide abatement by matching prices and emissions reductions in different model runs. For a given country or region, at a given emissions allowance price, the country/region reduces carbon emissions by a specified amount. Over a wide range of prices, the

[14] For more information about the Second Generation Model, refer to Edmonds et al. 1992.

relationship between the allowance price and emissions reductions can be traced out. This relationship depicts the approximate marginal abatement cost for the country or region. For the United States, we aggregated the cost functions for the non-carbon dioxide greenhouse gas emissions developed by the Interagency Analytical Team (1997) with the U.S. carbon dioxide cost function to generate a cost function for the entire basket of greenhouse gases. For all other countries and regions, we assumed the carbon dioxide cost function to hold for all six categories of greenhouse gases. Based on the pattern of U.S. abatement costs, this assumption for other countries would likely over-estimate the costs of abatement.

Abatement Cost Functions in Developing Countries

The marginal abatement cost functions for developing countries only include opportunities to reduce carbon dioxide released through energy consumption. Given that numerous options for abatement of other greenhouse gases and sequestration projects in these countries exist, these functions in fact over-estimate the costs of developing country participation.

Energy Efficiency Improvement

Energy efficiency improvements over time -- defined as the rate at which the total use of energy falls relative to GDP -- are attributable to three factors: changes in energy conservation due to price changes; the effects of non-price policy measures to improve energy efficiency (such as government support of R&D); and *autonomous* increases in energy efficiency. The first factor reflects the incentive provided by higher energy prices for firms and households to reduce energy consumption through efficiency measures and thereby make the economy as a whole more energy efficient. The second factor reflects the potential influence of a wide range of non-price public policies to improve the efficiency with which energy is used in the economy. For example, measures could be undertaken to speed the rate of diffusion and adoption of technologies which can simultaneously lower energy use and household and business energy bills. Finally, energy efficiency improvements occur over time which are independent of both prices and energy policies. For example, in the United States, the gradual transition from a manufacturing economy to a less energy-intensive service economy has improved the energy efficiency of the economy. The *autonomous energy efficiency improvement factor (AEEI)*[15] reflects only the pace of

[15] The Autonomous Energy Efficiency Improvement should be distinguished from the annual energy efficiency improvement used by some in the literature. The annual rate includes the autonomous component as well as price-induced and non-price (continued...)

efficiency improvements that are purely autonomous and thus independent of both energy prices and energy policies.

In modeling energy efficiency improvement, these three components are addressed in different ways. For the *autonomous* energy efficiency factor (AEEI), a plausible assumption is an improvement of about 1.0 percent per year. The developers of the Second Generation Model employ an AEEI of 0.96 percent per year as their default energy efficiency assumption. Similarly, the Energy Information Administration analysis (see Energy Information Administration 1997a) assumes a pace of energy efficiency improvement of 0.9 percent. In this analysis, we used the SGM default assumption concerning the autonomous energy efficiency parameter. For price-induced changes in energy efficiency, the model generates its own forecasts of changes in energy consumption that reflect the effects of greenhouse gas permit prices on energy prices.

Economists have traditionally had difficulty in modeling non-price policy-induced shifts in energy efficiency. For example, it is hard to assess the likely future pay-off from investments in energy R&D, although historical estimates of the rate of return to society from such investments are substantial. Similarly, the series of policy measures proposed by the Administration -- such as the Administration's electricity restructuring proposal, the Climate Change Technology Initiative, its voluntary sectoral initiatives, the federal sector's own energy efficiency program or other measures that could be adopted to spur the diffusion and adoption of existing technologies -- could substantially reduce the cost of mitigation and increase the amount of reductions achieved domestically. However, models like the Second Generation Model do not have the capacity to quantify these potential payoffs.

Some authorities in the field of energy policy, using an engineering approach rather than an economic paradigm, have sought to quantify the extent to which policy initiatives could spur more rapid improvements in energy efficiency. Experts at five national laboratories managed by the Department of Energy found that a third of the emissions reductions necessary to return to 1990 levels by 2010 could be achieved through the adoption of existing energy-efficiency technologies at no net resource cost. This translates into a non-price policy related efficiency contribution of 0.3% per year (Interlaboratory Working Group on Energy-Efficient and Low-Carbon Technologies 1997). The National Academy of Sciences reached qualitatively similar conclusions in a 1992 report. As reflected in the Department of Energy study, if a higher rate of energy efficiency improvement were achieved, the United States could meet a correspondingly larger fraction of its commitment through domestic reductions potentially at lower permit prices.

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[15](...continued)
policy-induced components.

Trading Scenarios

Intergas Trading

We assumed that trading occurs across all gases based on 100-year global warming potential values.

Trading Blocs

The Administration assessed three different industrialized country trading blocs.

- Annex I implies trading among all Annex I countries.

- Umbrella without Eastern Europe refers to trading among a subset of Annex I countries, excluding participation by the European Union and Eastern European countries.

- Umbrella with Eastern Europe refers to trading among a subset of Annex I countries, excluding participation by the European Union.

In addition, we assessed two forms of developing country participation in conjunction with the industrial country trading blocs.

- Developing countries generate emissions credits through the Clean Development Mechanism and sell them internationally. The CDM is assumed to provide 20% of emissions reductions that a country would otherwise undertake if it agreed to a target at business as usual and participated in international trading.

- Key developing countries are assumed to adopt emissions growth targets equal to their 2010 business as usual emissions level and participate in international emissions trading.

Trading across Time

This analysis assessed the permit price in 2010, the midpoint of the first commitment period. Since SGM is a computable general equilibrium model, all outputs are predicated on the full use of the economy's resources, so the analysis implicitly assumes an averaging out of business cycles, weather induced energy use fluctuations, and other short-term phenomena. This smoothing out is consistent with the effect of the five-year averaging period between 2008 and 2012. The permit price estimates for 2010 therefore provide a reasonable representation of the average permit price over 2008-2012.

Banking

This analysis did not incorporate the banking provision in the Kyoto Protocol. To model banking behavior, it is necessary to know the emissions targets for subsequent commitment periods. Since these targets have not been established yet, any assumption about future emissions targets would be speculative.

Identifying market clearing prices for trading blocs

After developing the baselines and cost functions, we calculated the market clearing prices for the trading blocs. Market clearing prices were estimated by constructing functions for the marginal cost of abatement of greenhouse gas emissions in each trading bloc. Given the greenhouse gas emissions reductions required by the Kyoto agreement for the countries within the trading bloc, these functions allow for the identification of marginal cost of abatement, and the unique price for permits traded among the countries comprising the bloc.

Calculating the Effects on Energy Prices

Reducing greenhouse gas emissions, in particular carbon dioxide emissions, would, in effect, modestly raise energy prices. At the same time, these higher prices would have the effect of reducing energy consumption by a modest amount, as firms and households cut back on some low-value uses of energy. Tradable greenhouse gas permits would also cause some shift in the fuel mix, away from carbon-intensive fuels like coal, and toward carbon-lean and carbon-free fuels, like natural gas, nuclear, and hydropower. Households would hardly notice this fuel mix shift, however, as most of it would occur at power plants.

Summary of Assumptions of Illustrative Analysis

The following list summarizes the assumptions in the illustrative modeling analysis described in the preceding section on methodology.

- Efficient and effective domestic trading of emissions allowances.

- International trading of emissions allowances (within each of three possible blocs).
  - Efficient and effective Annex I trading.
  - Efficient and effective Umbrella trading.
  - Efficient and effective trading with developing countries that adopt emissions targets.

- Trading across all six categories of greenhouse gases.

- Autonomous energy efficiency improvement (AEEI) value of 0.96% per year.

- No banking of emissions allowances to second or later commitment periods.

- Emissions targets are expressed in terms of all six categories of greenhouse gases.

- Marginal abatement costs for carbon dioxide from SGM outputs.

- Marginal abatement costs for non-carbon dioxide greenhouse gases for U.S.

- Marginal abatement costs for non-carbon dioxide greenhouse gases for other countries assumed to be the same as the costs for carbon dioxide.

- No emissions mitigation through carbon sinks for any country included in the analysis (see p. 62).

- No emission reductions from the Administration's electricity restructuring proposal included in the analysis (see p. 64).

- No emissions reductions from the Climate Change Technology Initiative included in the analysis (see p. 64).

- No emissions reductions from industries' voluntary plans through the Administration's industry consultations included in the analysis (see p. 65).

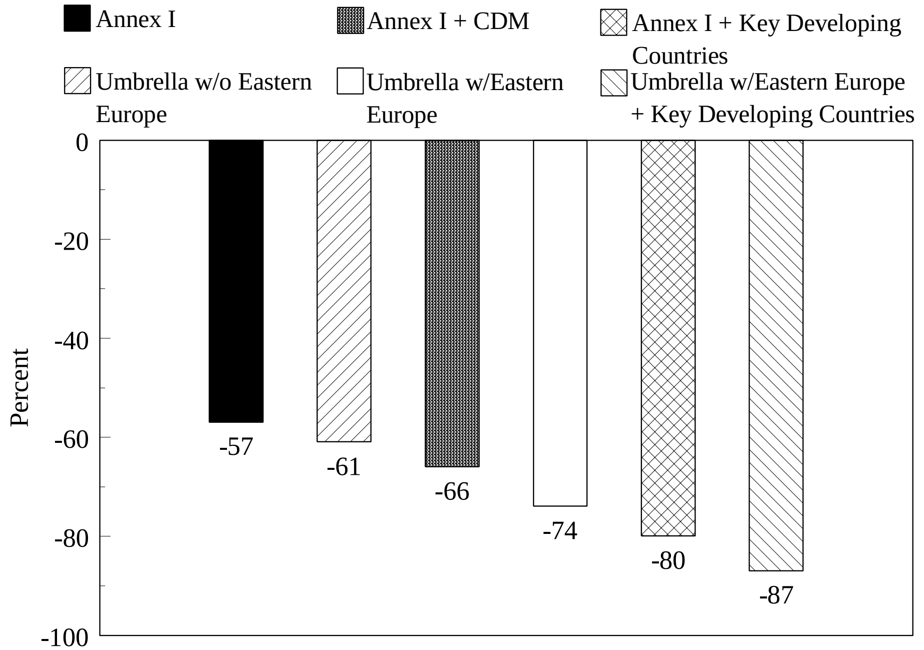
- No emissions reductions from the Federal government's energy efficiency initiative included in the analysis (see p. 66).

- No estimate of the benefits of addressing risks associated with climate change (see p. 69).

Economic Cost of the Administration's Policies to Reduce Greenhouse Gas Emissions in the Illustrative Analysis

The flexibility measures embodied in the Kyoto Protocol and the Administration's climate change approach could dramatically reduce the costs of complying with the Protocol (see Figure 19 and Table 4.) An effective international market for trading emissions permits among industrialized countries -- even without taking into account the added benefit of including key developing countries -- would potentially lower the resource cost to the United States of climate change policy by more than half relative to a scenario in which all abatement is performed domestically and would lower the price for emission permits (expressed as carbon equivalent) by nearly three

Figure 19. Percentage Reductions in Resource Costs Relative to "Domestic Only" Abatement Under Various Trading Scenarios



fourths.[16] If international trading took place only among "umbrella countries" (Annex I except for, in one scenario, the European Union, and, in another scenario, the European Union and Eastern Europe) resource costs could drop by 60-75% as compared to the domestic only cost, while permit prices could drop by 75-85% compared to a "domestic only" approach. Trading among industrialized countries alone could bring costs down into a relatively modest range.

An effective Clean Development Mechanism combined with industrialized country trading could reduce resource costs by two-thirds to four-fifths and could lower permit prices 79 - 88% compared to a domestic only approach. Finally, if some developing countries adopt growth emissions targets and participate in an effective trading system, the total resource cost to the United States could fall by 80 - 87% compared to a domestic only approach, while permit prices could sink by 88 - 93% compared to a domestic only effort.

Table 4. Permit Prices and Resource Costs Relative to "Domestic Only" Abatement of Various Trading Scenarios

Trading Scenario	Percent Reduction in Permit Price (relative to domestic only)	Percent Reduction in Resource Cost (relative to domestic only)
Annex I	72%	57%
Umbrella (with Eastern Europe)	85%	74%
Umbrella (without Eastern Europe)	75%	61%
Annex I + Key Developing Countries	88%	80%
Umbrella (with Eastern Europe) + Key Developing Countries	93%	87%
Umbrella (without Eastern Europe) + Key Developing Countries	91%	83%
Annex I + CDM	79%	66%
Umbrella (with Eastern Europe) + CDM	88%	80%
Umbrella (without Eastern Europe) + CDM	82%	71%

[16] "Resource cost" refers to the direct cost to the U.S. economy of meeting its Kyoto target measured as the cost of emissions abated domestically plus the cost of purchases of international emissions allowances and emissions credits by U.S. firms. "Permit price" refers to the price paid for a permit to emit one metric ton of carbon equivalent. The permit price can be translated readily into an added increment for U.S. energy prices. See, for example, Table 6.

The Administration supports effective international trading and meaningful participation by key developing countries. An assessment using the SGM model that accounts for effective trading and developing country participation yields permit price estimates ranging between $14/ton and $23/ton, and resource costs between $7 billion and $12 billion/year (see Table 5). The range reflects uncertainty about the extent of Annex I participation in international trading.

Table 5. U.S. Permit Prices and Resource Costs Under the Administration's Policies

Trading Scenario	**Permit Price**	**Total Resource Cost**	**Share of 2010 GDP**
Umbrella with Eastern Europe + key developing country participation	$14/ton	$7 billion/year	0.07%
Annex I + key developing country participation	$23/ton	$12 billion/year	0.11%

The illustrative modeling analysis does not account for several key components of the Kyoto Protocol and the Administration's policies to reduce greenhouse gas emissions. These key issues include the benefits of reducing net emissions through carbon sinks, the Administration's electricity restructuring proposal, the Administration's Climate Change Technology Initiative, the Administration's sectoral consultations to encourage and support voluntary efforts by U.S. industry to undertake emissions reductions, including the provision of credit for early action, and the Administration's efforts to reduce federal energy use. Each of these factors has the potential to significantly increase the amount of reductions made domestically, while lowering the level of permit prices. The model estimates do incorporate the effects of higher energy prices on energy efficiency: results reflect annual rates of energy efficiency improvement of 1.10 - 1.21%, where 0.96% per year is the autonomous energy efficiency improvement and 0.14 - 0.25% is the price-induced energy efficiency improvement. However, any additional payoffs from the CCTI or electricity restructuring are not included in this range. The illustrative model also does not account for ancillary benefits of reducing greenhouse gas emissions, such as improved local air quality, nor does it account for the benefits of averting the risks of climate change (see pp. 66, 69). For a discussion of these cost mitigating factors, see page 62.

U.S. Energy Prices

Under the assumptions of the Administration's analysis, permit prices in the range of $14/ton to $23/ton translate into energy price increases at the household level between 3 and 5%. As Table 6 illustrates, the price increases for electricity and an array of fuels would be modest, and in several cases, the prices faced by consumers, even under the $23/ton permit price, would be lower in real terms than prices experienced today (see Appendix D for long-term energy price trends). By 2010, the increase in energy cost for the average household expected with permit prices between $14/ton and $23/ton would range between $70 and $110 annually, but this would be roughly offset by cost-savings associated with the Administration's electricity restructuring proposal.

Table 6. U.S. Energy Prices Under Permit Prices of $14/ton to $23/ton

Energy Source	**1996 Price**	**2010 BAU Price**	**2010, $14/ton**	**2010, $23/ton**
Electricity	6.9¢/Kwh	5.9¢/Kwh	6.1¢/Kwh	6.2¢/Kwh
Gasoline	$1.225/gallon	$1.259/gallon	$1.293/gallon	$1.314/gallon
Fuel Oil	$1.087/gallon	$1.092/gallon	$1.140/gallon	$1.170/gallon
Natural Gas	$4.25/mcf	$3.80/mcf	$4.00/mcf	$4.13/mcf

All data are in 1996 dollars. 1996 and 2010 BAU prices are from Energy Information Administration 1997a.

The average price of electricity is projected to fall between now and 2010 as a result of competition at the wholesale level, expected declines in coal prices, anticipated efficiency improvements, and falling capital expenditures (Energy Information Administration 1997a). Under business as usual, the average price of electricity in 2010 is projected to be 5.9¢ -- 1¢ below the average price in 1995. Permit prices of $14/ton to $23/ton would yield average electricity prices about 3 to 5% above this projected price of 5.9¢ (see Figure 20). In addition, the Administration's electricity restructuring proposal, by spurring competition at the retail level, is expected to cause electricity prices to fall an additional 10% on average. The electricity restructuring proposal with permit prices of $14/ton to $23/ton would yield electricity prices well below the business as usual projection for 2010 (see Figure 21). Refer to Appendix C for a discussion of the potential cost-savings associated with the Administration's electricity restructuring proposal.

Figure 20. Average U.S. Electricity Prices Under $14/ton to $23/ton Permit Prices, Excluding the Cost-Savings Associated with Electricity Restructuring

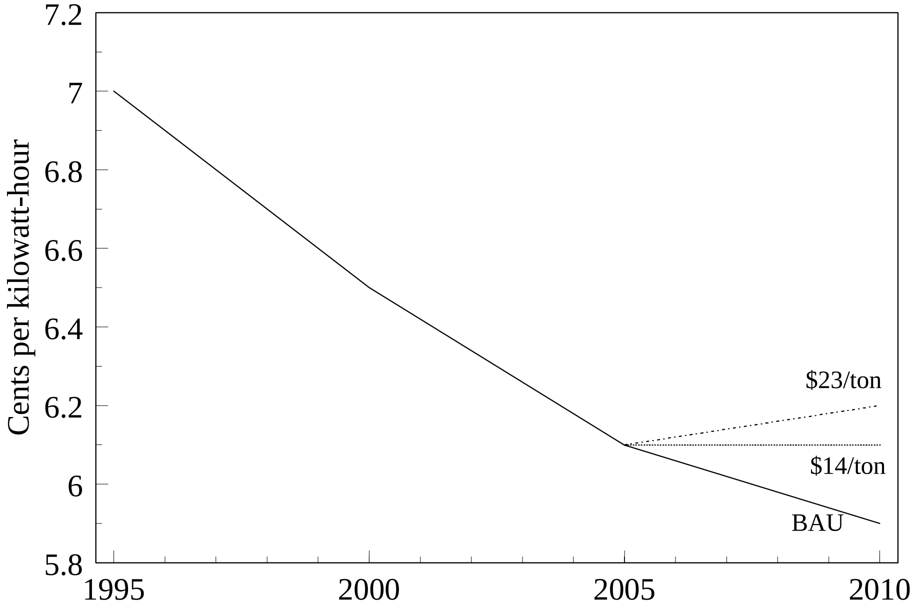
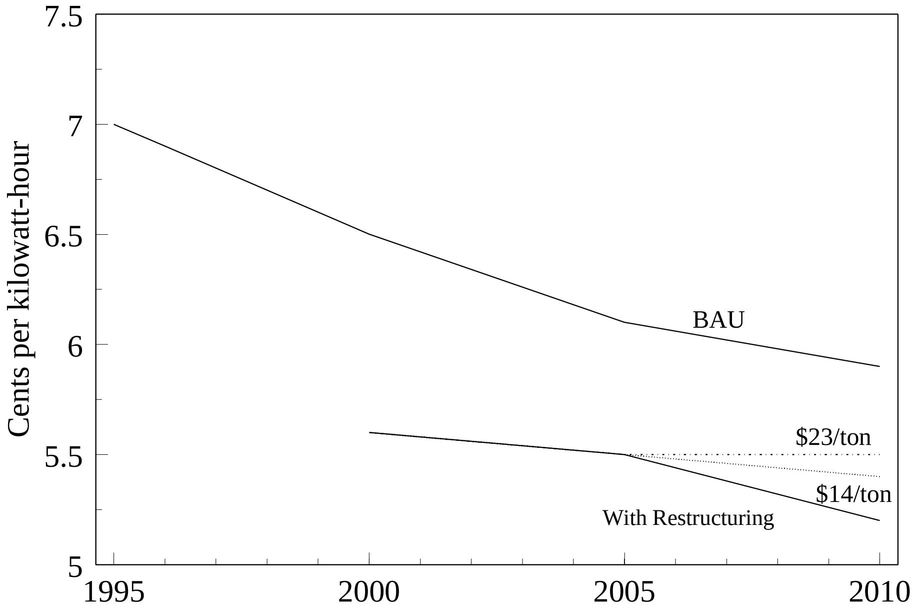
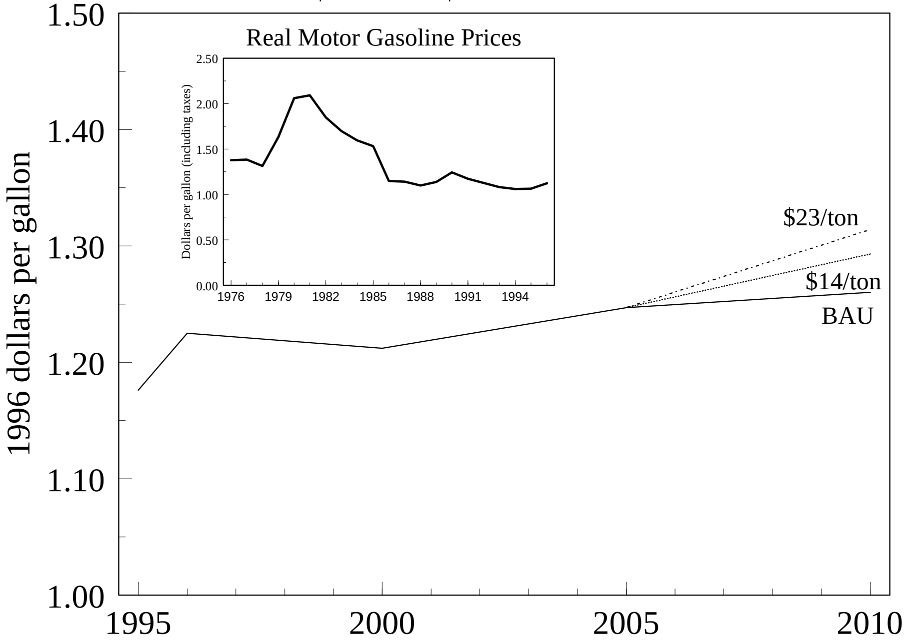


Figure 21. Average U.S. Electricity Prices Under $14/ton to $23/ton Permit Prices, Including the Cost-Savings Associated with Electricity Restructuring



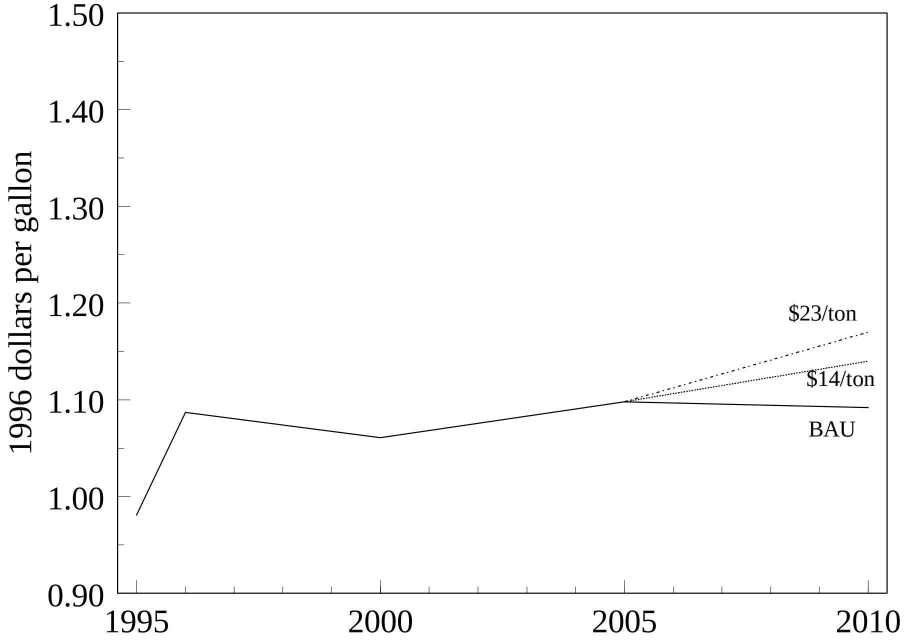
Permit prices of \$14/ton to \$23/ton also would be expected to increase gasoline prices by 3 to 4%, or 4 to 6¢ per gallon, relative to BAU projections for 2010 (see Figure 22). This increase, which would occur over the next decade, is smaller than the increase in gasoline prices over 1995-1996. Further, this change in gasoline price is small compared to historical changes in gas prices (see inserted figure). Over the past two decades, the average *annual* absolute change in the price of gasoline was 7.5%, about double the projected increase in gasoline prices over 12 years under the assumptions set out here.

Figure 22. Average U.S. Gasoline Prices
Under \$14/ton to \$23/ton Permit Prices



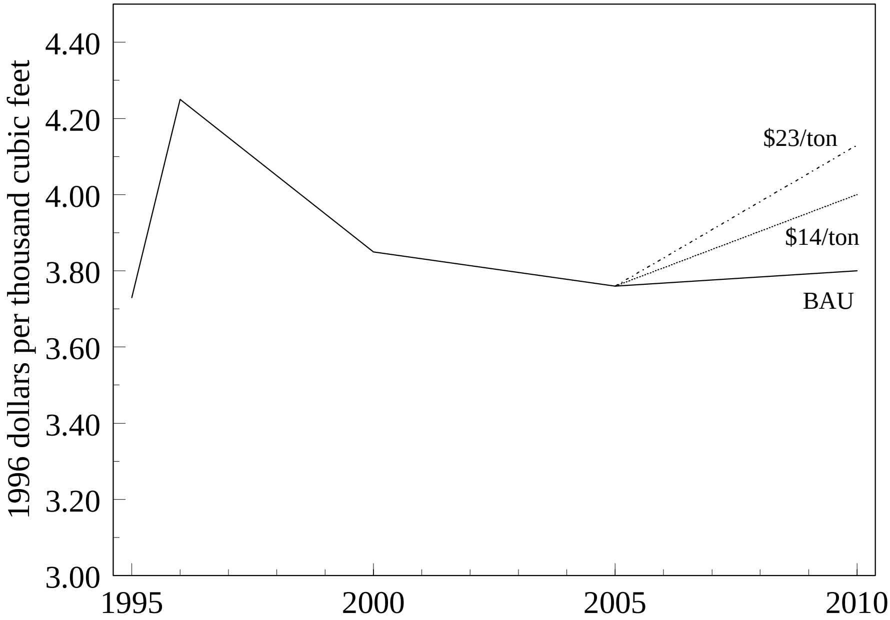
Permit prices of \$14/ton to \$23/ton could increase fuel oil prices by 5 to 8¢/gallon above their projected price in 2010 (see Figure 23). However, as in the case of gasoline, this increase is smaller, for example, than the jump in fuel oil prices experienced over 1995-1996.

Figure 23. Average U.S. Fuel Oil Prices
Under \$14/ton to \$23/ton Permit Prices



Between now and 2010, delivered natural gas prices are projected to fall because of anticipated efficiency improvements and an increasingly competitive market (Energy Information Administration 1997a). While greenhouse gas permit prices of $14/ton to $23/ton would likely result in modest increases in the price of natural gas relative to baseline projections, 2010 gas prices would still be below current prices (see Figure 24). Further, the price increases under these permit prices would be smaller than the price increase over 1995-1996.

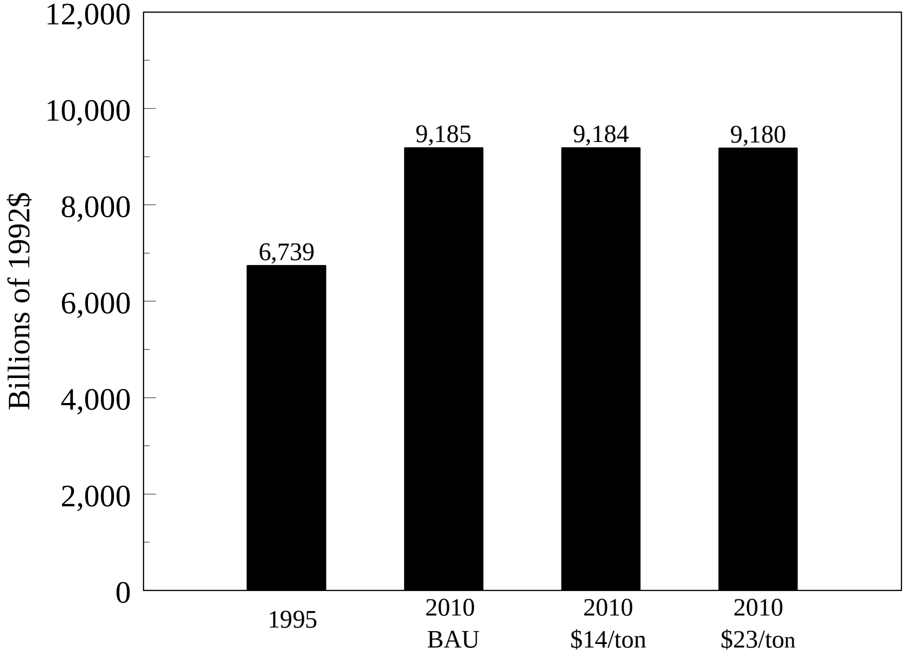
Figure 24. Average U.S. Natural Gas Prices
Under $14/ton to $23/ton Permit Prices



U.S. GDP, Investment, and Consumption

The Second Generation Model projects economic growth for the United States in its business as usual scenario through 2010 shown by the difference between the first two bars in Figure 25. Implementing climate policy through effective international trading in conjunction with meaningful developing country participation would have a negligible effect on economic output. A $14/ton permit price would result in a $1 billion (0.01 %) decline in GDP relative to business as usual. Under a $23/ton permit price, GDP would be $5 billion less in 2010 than it is projected to be otherwise.[17]

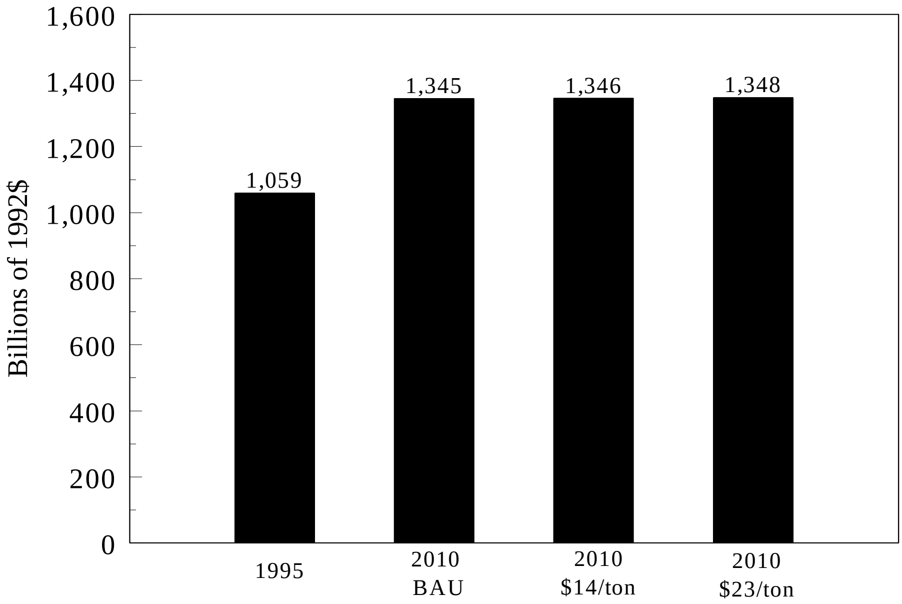
Figure 25. U.S. GDP Under $14/ton to $23/ton Permit Prices



[17] Note that the SGM GDP estimate does not reflect the effects of reducing non-carbon dioxide greenhouse gas emissions.

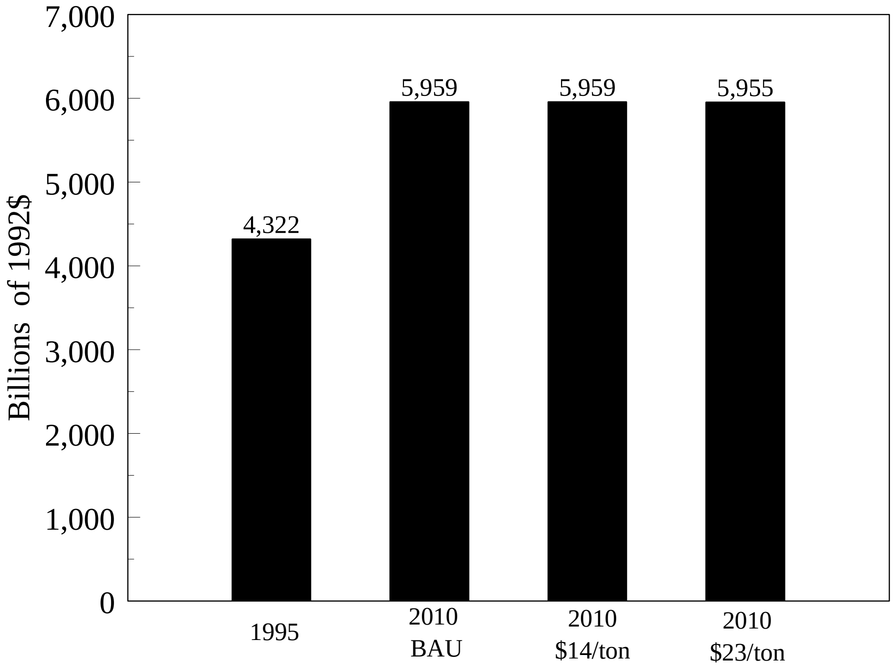
Permit prices of $14/ton to $23/ton imply a small increase in investment relative to business as usual (see Figure 26). Under a $14/ton scenario, investment would increase by $1 billion while a $23/ton permit price scenario entails a $3 billion increase in investment in 2010 relative to business as usual. This increase in investment reflects the adoption of energy efficient and carbon-lean technologies stimulated by the price of greenhouse gas permits.

Figure 26. U.S. Investment Under $14/ton to $23/ton Permit Prices



Permit prices of $14/ton to $23/ton would cause a slight shift from consumption to investment; however, this shift would be small. Under the $14/ton permit price scenario, the change in consumption would be insignificant relative to the business as usual baseline (see Figure 27). Under the $23/ton scenario, the shift would amount to a decline of about $4 billion in 2010.

Figure 27. U.S. Consumption Under $14/ton to $23/ton Permit Prices



Employment

The Second Generation Model is conditioned on the assumption that aggregate employment effects are negligible. Given the small projected energy price increases anticipated and the long lead time before any impact would occur, this assumption is appropriate. Although there may be job gains in some sectors and job losses in others, the analysis of the Kyoto Protocol with effective international trading and developing country participation suggests that there will not be a significant aggregate employment effect under permit prices of $14/ton to $23/ton. Some job loss could occur in energy-intensive sectors, although given the small predicted change in energy prices, impacts in most such sectors are apt to be modest. Further, new jobs will be created in other sectors -- such as in environmental protection technologies, energy production, and energy efficient technologies. Many of these are likely to be high-tech jobs that pay high wages. Nonetheless, as the President said in his October 1997 speech, where dislocations do occur as a result of policies to reduce greenhouse gas emissions, assistance should be provided to affected workers.

Additional Cost Mitigating Factors

Potential Benefits of Carbon Sinks

Various forestry and soil activities sequester carbon dioxide and thereby offset some emissions associated with industrial activity. Trees, other vegetation, and organic matter in soils take up carbon dioxide through photosynthesis and transform the carbon dioxide and store it in vegetative tissue. These carbon sinks can serve as opportunities to mitigate the emissions of carbon dioxide from fossil fuel combustion. For example, the Climate Action Report (1997) reported that gross anthropogenic greenhouse gas emissions in the United States in 1990 were 1,583 MMTCE. However, by including certain carbon sinks,[18] *net* greenhouse gas emissions totaled 1,458 MMTCE, or 8% lower.

[18] Note that carbon sinks, as defined in the Climate Action Report, are different from the set of forestry activities included in the sinks definition in Article 3.3 of the Kyoto Protocol. While the estimate of sequestration from the Climate Action Report indicates that the United States has been a net sink of carbon, it should not be construed to represent the U.S. carbon sink potential under the Kyoto Protocol. Moreover, the Climate Action Report estimate of carbon sequestration excluded below-ground sinks, such as soil sinks.

The Kyoto Protocol includes opportunities to reduce net emissions through carbon sinks. Certain forestry activities -- afforestation and reforestation net of deforestation -- will be used by countries with emissions targets to meet their commitments (Kyoto Protocol, Article 3.3). The Kyoto agreement does not include carbon sinks in calculating the emissions baseline, but does allow for countries to achieve their targets by accounting for sequestration during the commitment period by these forestry activities that occur between 1990 and 2012. For countries such as the United States, where acres of tree-planting exceed acres of tree-cutting annually, this provision illustrates another opportunity where the United States can reduce net emissions at low cost. In addition, the Protocol provides the option to include additional categories of carbon sinks, like agricultural soils and other land-use change and forestry activities, based on additional technical work and negotiations (Kyoto Protocol, Article 3.4). With these carbon sinks, the United States could more easily meet its target even without additional policies to specifically encourage sink activity. However, given the ongoing negotiations to develop rules regarding carbon sinks, the Administration employed the very conservative assumption that business as usual sink activity generates no net sequestration.

Complementing the opportunities to reduce net emissions domestically through existing forestry activities, several economic analyses indicate that policies could stimulate the creation of additional carbon sinks at low costs. Stavins (1996) derived a marginal cost curve for carbon sequestration for the United States based on his analysis of land use decisions between 1935 and 1984 for a set of counties in Mississippi, Arkansas, and Louisiana. He found that more than 150 MMTCE could be sequestered at $25/ton. Adams et al. (1993) assessed several different scenarios of tree planting on agricultural land and found that about 250 MMTCE could be sequestered at approximately $25/ton.[19] Studies based on engineering/costing models indicate that even more carbon could be sequestered at low costs (Moulton and Richards 1990). While the Administration's illustrative modeling analysis did not incorporate carbon sinks, these studies clearly illustrate the potential for carbon sequestration efforts to play a significant role in meeting our emissions target. These studies provide some evidence that carbon sinks in the United States and other countries could significantly reduce the international emissions trading price and, consequently, the costs of achieving the environmental objective.

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[19] Adams et al. (1993) provide their estimate in short tons, and for purposes of comparison, we have converted this estimate to metric tons.

Potential Emissions Reductions through the Administration's Electricity Restructuring Proposal

The Administration's Comprehensive Electricity Competition Plan (CECP) is estimated to reduce greenhouse gas emissions by about 25 to 40 million metric tons of carbon equivalent per year by 2010. Although competition will lower prices, which will tend to increase consumption, it will also provide a direct profit incentive for generators to produce more electricity with less fuel and improve energy efficiency as competitive sellers seek to maximize the value of their product offerings to buyers by bundling electricity with energy efficiency and management services. In the 2010 timeframe, the net result of retail competition in the absence of additional specific provisions to encourage renewables or subsidize investments in energy efficiency is expected to be nil or a small reduction in emissions.

Specific CECP provisions that will yield additional emission reductions include a renewable portfolio standard, a public benefits fund that will support renewable energy and energy efficiency investments, "green" labeling to help consumers who value clean energy choose it, and a net metering provision encouraging the installation of small renewable systems.

Potential Emissions Reductions through the Administration's Climate Change Technology Initiative

The President's Fiscal Year 1999 budget includes the Climate Change Technology Initiative (CCTI), a $6.3 billion package of tax cuts and R&D investments intended to spur the discovery and adoption of new technologies. The goal is both to stimulate the development of new energy-saving and carbon-saving technologies and to encourage the deployment of those that exist already. Many of the components of the CCTI reflect recommendations made in a recent report by the President's Committee of Advisors on Science and Technology (PCAST 1997).[20] PCAST found that "the inadequacy of current energy R&D is especially acute in relation to the challenge of responding prudently and cost-effectively to the risk of global climatic change from society's greenhouse gas emissions.... Much of the new R&D needed to respond to this challenge would also be responsive to the other challenges" (PCAST 1997, p. i). The report concluded that investments in energy R&D would generate economic and environmental benefits, especially in the long run.

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[20] The President's Committee of Advisors on Science and Technology was established in 1993 to advise the President on matters involving science and technology. PCAST consists of distinguished representatives from industry, academia, research institutions, and other non-governmental organizations.

Building on PCAST's recommendations, the proposed CCTI package contains $3.6 billion over the next five years in tax cuts for energy-efficient purchases and renewable energy, including tax credits of $3,000 to $4,000 for consumers who purchase highly fuel efficient vehicles, a 15 percent credit (up to $2,000) for purchases of rooftop solar equipment, a 20 percent credit (subject to a cap) for purchasing energy-efficient building equipment, a credit up to $2,000 for purchasing energy-efficient new homes, an extension of the wind and biomass tax credit, and a 10 percent investment credit for the purchase of combined heat and power systems. The package also contains $2.7 billion over the next five years in additional research and development investments -- covering the four major carbon-emitting sectors of the economy (buildings, industry, transportation, and electricity), plus carbon removal and sequestration, Federal facilities, and cross-cutting analyses and research. One example of the R&D effort is the Partnership for a New Generation of Vehicles (PNGV). PNGV is a government-industry effort to develop attractive, affordable cars that meet all applicable safety and environmental standards and get up to three times the fuel efficiency of today's cars. In FY99, the combined proposal for PNGV is $277 million, up from $227 million appropriated in FY98. If supported by the Congress, this effort could further improve energy efficiency and lower the cost of meeting our Kyoto target.

The Administration has not included quantitative estimates of emissions reductions associated with the Climate Change Technology Initiative in the modeling analysis. This reflects the uncertainty in calculating the payoffs from funding research and development. A fully funded CCTI would provide for additional U.S. emissions reductions and result in lower permit prices than there otherwise would be.

Potential Emissions Reductions through the Administration's Industry Consultations

Under the Administration's 1993 Climate Change Action Plan, many businesses and institutions are taking voluntary steps to improve their energy efficiency and reduce greenhouse gas emissions. According to the Climate Action Report (1997) the wide array of voluntary actions in that Plan are expected to reduce emissions by 76 MMTCE in the year 2000 and 169 MMTCE in 2010. Annual energy savings are projected to grow to $50 billion (1995 dollars) in the year 2010.

In October 1997, President Clinton called for sectoral consultations which will build on the voluntary efforts undertaken pursuant to the Climate Change Action Plan. One partnership already announced, the Partnership for Advanced Technology in Housing (PATH), sets goals for voluntary improvements in home energy use that would result in an estimated 24 MMTCE in reductions in 2010 while saving consumers $11 billion in home energy expenditures. The Administration will be seeking voluntary agreements with major energy-intensive industries and energy providers to yield further emissions reductions.

As the sectoral consultations are still at an early stage, it would be premature and difficult to incorporate emissions reductions from consultations into the illustrative modeling analysis. Based on the effectiveness of these approaches in the past, these consultations could produce a significant amount of cost-effective action in the coming decade.

Federal Energy Plan

In October, 1997, the President called for a series of steps to reduce energy use in Federal buildings, transportation fleets, and other equipment purchases, and to promote the use of renewable energy sources. As the nation's largest single energy user, the federal government spends nearly $8 billion each year for power to operate facilities, vehicles and industrial equipment, and over 90% of this energy derives from fossil fuels. Long-term savings in cost and energy use can be secured by making sure that purchases for federal facilities, transportation, and systems operations emphasize energy efficiency and that energy-intensive equipment be retrofitted wherever feasible. In addition, the federal government can expand the procurement of renewable and less carbon-intensive fuels.

Ancillary Benefits of Greenhouse Gas Emissions Reductions in the United States

Reductions in fossil fuel combustion typically lead to reductions in conventional air pollutants. These include sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter and volatile organic compounds. These reductions in emissions can have important implications for environmental quality and public health.

To estimate the ancillary benefits for the United States of the Kyoto Protocol, we employed the methods that were used for the Regulatory Impact Analysis (RIA) that the Environmental Protection Agency published in July 1997 for the revised national ambient air quality standards (NAAQS) for particulate matter and ozone. First, the DRI model was used to simulate the changes in fossil fuel combustion by region and economic sector that the Kyoto Protocol would bring about.[21] These changes in fuel

[21] DRI/McGraw-Hill U.S. Energy Model.

consumption were then used by Pechan Associates, an EPA contractor, to estimate changes in emissions of local air pollutants.[22]

Identification of the baseline from which to estimate emission reductions attributable to a carbon control strategy is complicated by the gradual transition to full attainment of the new NAAQS. In particular, states and emission sources could respond to a carbon control strategy by either replacing or maintaining NAAQS-related emission controls. Because of this uncertainty, ancillary benefits are treated as a range.

If ancillary benefits of carbon mitigation make the NAAQS-related emissions controls unnecessary, substantial costs for controlling pollution will be avoided. Reasonable estimates of the cost-savings per ton are approximately \$1,620 for NO_x and \$700 for SO_2, based on current information about the specific technologies likely to be avoided at utilities and large industrial sources. (These estimates are derived from the estimates of the incremental costs of tighter regional caps on NO_x and SO_2 emissions that were developed for the NAAQS RIA.) Given these unit values, the value of these cost-savings for sulfur dioxide is about \$360 to \$600 million per year, and for NO_x is about \$370 to \$610 million per year. Adding these together gives cost savings of about \$0.74 to \$1.2 billion per year.

If carbon mitigation partially supplements, rather than displaces, NAAQS-related controls, valuing the ancillary health and welfare benefits requires (1) an estimate of the changes in air quality, and (2) an estimate of the value in dollars of such changes. For this analysis we employed the methodologies and tools used for the NAAQS RIA of July 1997. However, we note that in this area, as others, there is substantial uncertainty surrounding the appropriate methodology. The academic literature is in flux and provides a number of possible approaches.

Since the measure of air quality responsible for most of the quantifiable benefits is the abatement of fine particulate matter, we do not quantify changes related to ozone, and concentrate instead on fine particles ($PM_{2.5}$). Reducing $PM_{2.5}$ concentrations yields a wide variety of benefits. Our analysis indicates that the reductions in $PM_{2.5}$ attributable to carbon mitigation that corresponds to the \$14/ton case would lead to between \$1.1 billion and \$5.7 billion in benefits annually. Similarly, the reductions in $PM_{2.5}$ attributable to carbon mitigation in the \$23/ton case would lead to between \$1.8 and \$9.4 billion in benefits. Although these plausible ranges appear large, they are consistent with prior estimates, e.g., in the NAAQS RIA, and reflect a variety of uncertainties in the nature of the health effects.

In this scenario, there are additional ancillary benefits in the form of avoided NAAQS-related air pollutant control costs. Specifically, for the two pollutants

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[22] See E.H. Pechan and Associates 1997a, b.

governed by cap and trade programs (SO_2 and NO_x), avoided control costs total about $450 million in the $14/ton case and about $740 million in the $23/ton case. Total annual ancillary benefits for this valuation approach range from about $1.6 billion to $6.2 billion for the $14/ton case and from about $2.5 billion to $10.0 billion for the $23/ton case.

Thus as a conservative estimate, a quarter of the costs of the Kyoto agreement are offset by these ancillary benefits, although there is substantial uncertainty about these estimates.

It should be noted that the level of ancillary benefits from carbon mitigation increases with the extent of domestic mitigation and decreases to the extent that mitigation is based on purchasing international emissions allowances. In general the magnitude of these ancillary benefits depends on the type of regulation of air quality and emissions of local air pollutants, as well as baseline local air quality.

Greenhouse gas mitigation strategies will result in additional reductions of other air pollutant emissions, including several that have not been quantified (see Table 7). In particular, greenhouse gas mitigation strategies will result in additional reductions in heavy metals, acetaldehyde, formaldehyde, organic aromatics, polycyclic aromatic hydrocarbons (PAH), and chlorinated dioxins and furans. These substances are capable of producing a wide array of health and environmental effects, including some forms of cancer. Exposure to these substances at some concentrations can cause effects in addition to cancer; these may range from respiratory problems to reproductive and developmental effects. Further, although reductions in nitrogen and sulfur dioxide emissions were quantified in dollar terms, the estimated values exclude the mitigation of adverse impacts on agricultural and forestry yields, aquatic and terrestrial ecosystems, and recreational fishing.

Table 7. Unquantified Ancillary Emissions Benefits

Effect Category	**Effects**	**Other Possible Effects**
Human Health	Cancer Mortality Non-cancer Effects -neurological -respiratory -reproductive -hematopoietic -developmental -immunological -organ toxicity	
Ecological	Effects on: -wildlife -plants -ecosystem -biological diversity	Loss of habitat for endangered species
Welfare	Decreased recreation opportunities Decreased agricultural yield Decreased visibility	Loss of biological diversity Building deterioration

Benefits of Averting Climate Change

In conducting this analysis, the Administration has not attempted to quantify the benefits of mitigating the risks of climate change. While several economists have estimated the damages of global warming under a doubling of atmospheric concentration (Cline 1992; Fankhauser 1993; Nordhaus 1994), they all assumed an endpoint -- an atmospheric concentration, and subsequently, an increase in global temperature. However, the Kyoto Protocol only stipulates an emissions path through 2012. To calculate the benefits of averting climate change-induced damages, it is necessary to know the emissions path for many years beyond 2012. Thus while the benefits of getting started on the Kyoto path to reducing greenhouse gas emissions may be quite large over time, we cannot estimate these benefits without knowing where the path goes in the years after the Kyoto compliance period.

Cline (1992) assessed the economic damages from warming associated with two temperature increases: 2.5° C (4.5° F) and 10° C (18° F). He presented the former temperature change as the likely effect of a doubling of the atmospheric carbon dioxide concentration and the latter temperature change as the result of “very long term warming." Under the scenario where the temperature increases 4.5° F, Cline found that the annual damage to the United States would be about 1.1% of GDP, or about $89 billion in today's terms.[23] Cline's "very long term warming" scenario resulted in economic damages of about 6% of GDP.

Cline's estimates of annual economic damage of global warming take account of the following categories of impact: agriculture, forest loss, species loss, sea-level rise (including costs of constructing dikes and levees, wetlands loss, and drylands loss), electricity requirements, non-electric heating, human amenity, human life, human morbidity, migration, hurricanes, construction, leisure activities, water supply, urban infrastructure, and air pollution. Cline provides only qualitative assessments for several categories. In addition, he found that non-electric heating expenditures decline with global warming, so this is actually considered a benefit, not a cost, associated with warming.

The economic damage under a doubling of the atmospheric carbon dioxide concentration found by Cline is not significantly different in magnitude from the results of Nordhaus (1994) and Fankhauser (1993). Nordhaus estimated that a temperature increase of 5.4° F would result in annual costs of about 1% of GDP. Fankhauser found that under the same 5.4° F temperature increase the annual costs of warming would be about 1.3% of GDP for the United States, and 1.5% of GDP worldwide. However, the similarity among the aggregated estimates of these three researchers masks both the differences in their methodologies and the true uncertainty associated with long-term forecasts of the damages from given increases in global warming. Different researchers account for different categories of damages, and even within the same category, they may estimate different effects. More importantly, the estimates are all fundamentally based on extrapolations from current and past experience, and may not fully incorporate effects that will become apparent only with future experience.

International Impacts Associated with Reducing Greenhouse Gas Emissions

Just as in the United States, all Annex I countries would benefit significantly from effective implementation of the Kyoto Protocol's flexibility mechanisms. Further, Non-Annex I countries would accrue three kinds of benefits: 1) under international trade with binding targets slightly below business as usual and the CDM, they will enjoy economic gain from trade in emissions allowances; 2) reductions in carbon

[23] Cline's original estimate is quoted in 1990 dollars. The figure given above translates the Cline estimate into 1997 terms by scaling it to 1997 GDP.

emissions will reduce emissions of local air pollutants; and 3) contributing to lower global greenhouse gas emissions would further reduce the risks of climate change, to which they are, in many cases, the most vulnerable and the least able to adapt.

- **Economic benefits:** With growth targets, developing countries could enjoy substantial net gains through the international sale of emission reductions achieved at lower cost than the world price. Such participation by developing countries in international emissions allowance markets would lower the costs to industrial countries, including the United States, of meeting their Kyoto targets. In particular, costs would be lower than with trading among only Annex I countries. On a project-by-project basis, the Clean Development Mechanism would also result in net gains to developing countries and cost-savings to industrial countries. Given the anticipated difference in scale, a system including effective trading of developing countries' emissions would yield greater gains to developing countries and greater cost-savings to industrial countries than the Clean Development Mechanism.

- **Environmental benefits:** Developing country growth targets would lower global greenhouse gas emissions relative to a world with only Annex I targets. To the extent that these lower global emissions further reduce the risks of climate change, the more vulnerable developing countries would benefit. Further, reducing carbon dioxide emissions generates ancillary air quality benefits by reducing emissions of particulate matter, sulfur dioxide, and nitrogen oxides. By adopting a growth target and engaging in trading, developing countries could achieve environmental benefits not achievable by pursuing CDM alone.

Effects of Climate Change Policy on U.S. Competitiveness

Some have expressed concern that the Kyoto Protocol might adversely affect the competitive position of American industry. In general, structural changes in the economy have the effect of expanding some sectors and contracting others. But to provide some perspective on this issue, consider the following facts. First, on average, energy constitutes only 2.2 percent of total costs to U.S. industry. Second, energy prices already vary significantly across countries. For example, premium gasoline cost $1.28 per gallon in the United States in 1996, but only 8 cents per gallon in Venezuela. Similarly, gas prices were $3.71 per gallon in Switzerland and $4.41 per gallon in France (Bureau of the Census 1997). Electricity prices also vary significantly: in the U.S., for industry, they were 5 cents per kilowatt hour in 1995, a fraction of prices in Switzerland of 13 cents per kilowatt hour (OECD/IEA 1996). Yet U.S. industry did not move en masse to Venezuela, nor did Swiss industry move to the United States. Third, roughly two-thirds of all emissions are not in manufacturing at all, but in transportation and buildings, sectors which, by their very nature, are severely limited in their ability to relocate to other countries.

Evaluating how the Kyoto Protocol could affect competitiveness of a few specific manufacturing industries -- especially those that are energy-intensive, such as aluminum and chemicals -- is complex. However, the modest energy price effects associated with permit prices of $14/ton to $23/ton would likely have little impact on competitiveness.

Further, there is no reason to expect that mitigating climate change would necessarily have a negative effect on the trade balance. Indeed, the efforts to reduce greenhouse gas emissions would likely decrease oil exports to the United States, benefitting the trade balance. In short, we believe that the reason we need developing country participation is primarily because the problem is global and cost-effective solutions are essential, rather than to avoid adverse effects on competitiveness.